DIFFERENCES IN THE DYNAMICS OF SWEAT SECRETION IN ATOPIC CHILDREN*

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Studies of quantitative and qualitative changes in the eccrine sweat secretion have recently concerned themselves with not only the changes in the concentration of sweat electrolytes (1, 2, 3, 4), the regulation of water output onto the skin surface in relation to homeostasis and skin vasomotor regulation (5, 6, 7, 8) but also in relation to electrophysical phenomena on the skin which are either directly or indirectly influenced by the quantity of water and electrolytes contained therein (9, 10, 11, 12).

One of the questions posed by the above-named clinical and theoretical problems is the question of registering and evaluating the sweat secretion as a continuous function (13, 14, 15). We have studied this problem in chronic lichenified lesions of atopic dermatitis where the sweat output and absorption is hypothetically supposed to be in pathogenetic relationship (16, 17, 18, 19, 20).

On the basis of previous work it was possible to conclude that a lichenified lesion in typical localization responds with an increased sweat output to impulses which do not elicit any response in healthy skin (21). In order to confirm the fact that the sweat threshold in these locations is decreased, we have tried to record the sweat output as a function of time, assuming that the secretion produced in a muscarin receptor would be of a different character from that stimulated centrally.

The majority of known hygrometers is inadequate for evaluating sweat output dynamics because of their great inertia (22, 23, 24, 25, 26). For the purpose of our experiments a hygrometer with a time constant $\tau < 0,5$ sec, has been devised. It is, principally, a detector with a layer of alkali chloride solution in glycerin. In order to accelerate the response of the device, we fixed this sensitive matter to bentonite and made of this suspension a thin sensitive layer between the electrodes. Both the body of the detector and its afferent tubing is made of polyethylene. Air is sucked through the measuring system by means of vacuum tubes and through a manostat and a flowmeter. We determined the decrease of potential which arises when a constant (1.10^{-7}A) current flows through the sensitive layer of the detector, the resistance of which is in order of 10 MΩ. A Foreometer Prema was used as a measuring device, providing constant current and containing simultaneously a direct current voltmeter with high input resistance. The recorder Metra RG 140 was used for recording. (Figure 1)

The whole device insures a true recording of rhythmical sweat output. By means of an evaporator we found that the excursions of the recorder are in direct ratio to air humidity flowing through the detector. It should be noted that if measurings have been taken for fourteen days, it is necessary that the chamber be coated with a new sensitive layer.

The sampling cell is placed onto the desired skin location, thus closing a circuit through which dried air flows. Water vapor which is liberated from the skin by means of sweat secretion is now transported into the detector. By regulation of the air flow, the sensitivity of the record can be readily changed and be made to correspond to the given amplitude in sweat secretion. The quantity of excreted sweat may be established by comparing the size of the signal gained by measuring with the signal obtained by permitting room air to flow through the detector. The humidity of room air is measured by means of a psychrometer. If the air flow is adequately controlled, then the mean level of the sweat secretion record may be set to the same value obtained by permitting room air to flow through the detector, thus giving the standard value. The quantity of excreted sweat can be calculated from the humidity of the standard value in comparison with the obtained data. The areas limited by the registrated curves are then compared, and the results related to units of time and units of sampling cell area.

For instance in graph 7 the ratio of areas d and e was 280:290 mm², area e was given by

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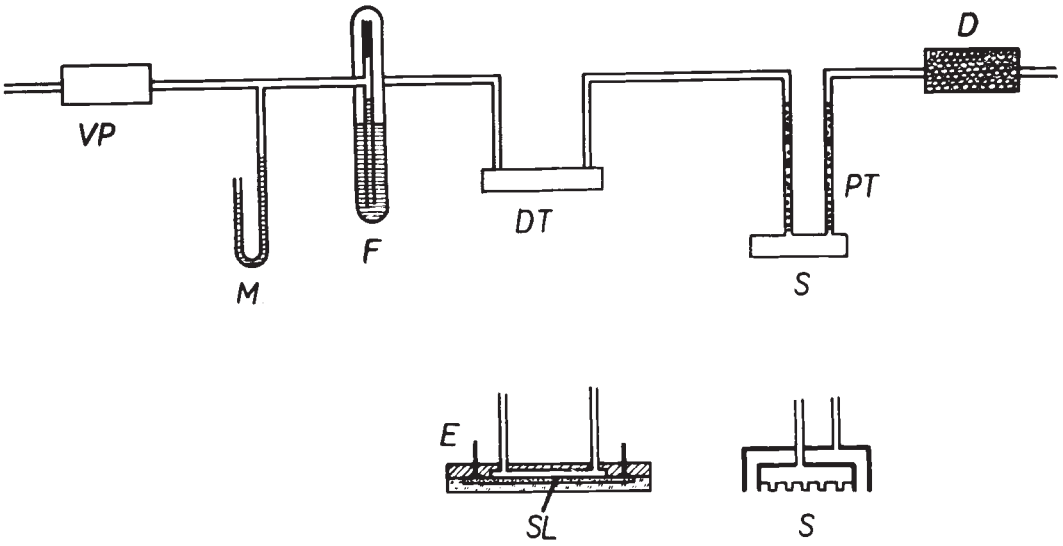


FIG. 1. Cross section of hygrometer. The air is sucked in by a vacuum pump (VP), through a manometer with manostat (M) and flowmeter (F) into the detector (DT). The circuit is closed as the sampling cell (S) is fixed to the skin. Dry air then flows from the drying vessel (D) through the sampling cell (S) and polyethylene tubing (PT), where water vapor from the skin is directed into the detector (DT). After taking the sampling cell off the skin, room air flows into the detector, its moisture having been determined by means of a psychrometer. The current of moist air in the slit above the sensitive layer (SL) gives rise to conductive changes between the electrodes. (E)

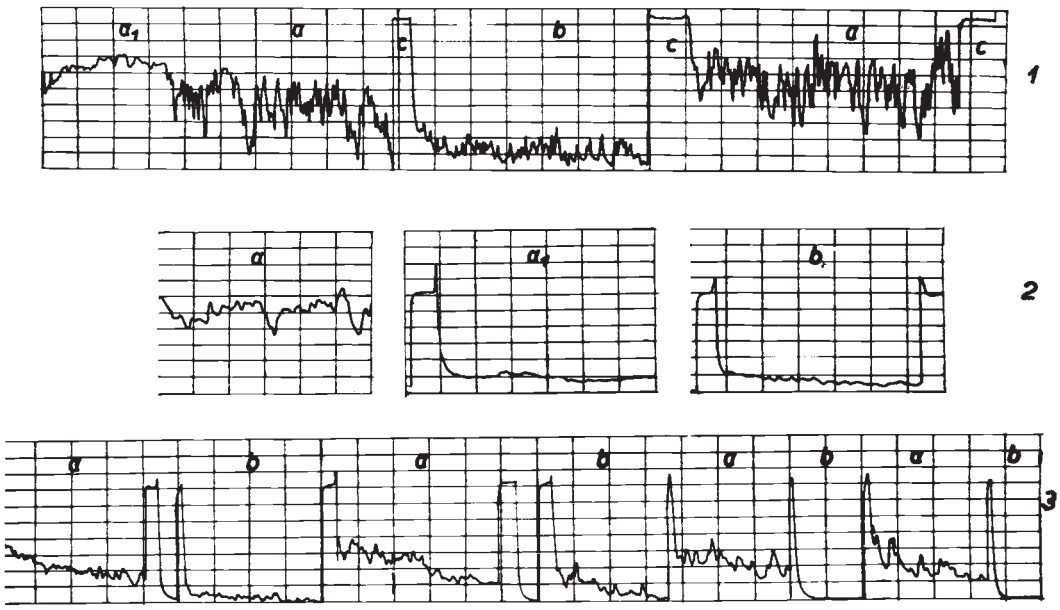
measuring room air, the humidity of which was found to be 14.5 mg water per liter (70% relative humidity at 23° C). The area d was obtained during the experiment when the air-flow through the device was found to be 5 l per hour (83 ml min^{-1}). The area of the sampling cell was 3.14 cm^2.

Therefore the water vapor must be equal to:

$$X = \frac{280 \times 14.5 \times 0.083}{290 \times 3.14} = 0.37 \text{ mg cm}^{-2} \text{ min}^{-1}$$

The described method was used to measure the sweat output in 25 children from 5–15 years of age with atopic dermatitis. The test was performed under the same conditions for each case at a room temperature of about 25–27° C. Measured exercise (squatting) was used to evoke an intermittent sweat response. The sampling cell was applied to typical lichenified areas of predilection (the flexures), and if the eruption happened to be disseminated, then the location of the sampling cells was not limited to the areas of predilection. The skin area adjacent to the measured lesion served as a control. Thus, if the test was performed in an area of predilective, then the control was also performed in this location to eliminate the possibility of differences resulting from different locations. In cases in which the flexures were affected unilaterally, the control test was performed on the contralateral intact skin area. Graph 1 is typical, representing a high sweat output of a lichenified area. The first three minutes (a^1) of the record are continuous in character (hyperstimulation) with a sudden change to a typically pulsing sweat output (a) with an average of 8 cycles per minute. The corresponding sweat output in the unaffected flexor is continuously low (b), whereas at location (a) it continues high. This intense sweat secreting activity may be suppressed by atropin. Graph 2 represents the sweat output of a lichenified area on the volar aspect of the forearm (a), part of it having been suppressed by atropin iontophoresis (a^1), the result being similar to that of the unaffected area (b).

If a lower threshhold of the neurosecretive junction to impulses is actually involved, then a longer duration of the sweat response in the affected area can be expected in comparison with the unaffected one. This is demonstrated by graph 3. Both the lichenified area of the forearm (a) and the unaffected area adjacent to it (b)



GRAPH 1. Sudomotoric curves of the affected areas (a) and corresponding control areas (b). There are records of room air moisture after having taken the sampling cell off the skin (c). Flow speed of record: 1 part corresponds to one minute.

GRAPH 2. Another type of sudomotoric curve from an affected area where sweat secretion has been suppressed by atropine (a_1); the curve is similar to the control one (b). Iontophoresis of 3 minute duration was performed from the anode, 1% solutions, 1.5 mA, electrode area 5.4 cm^2.

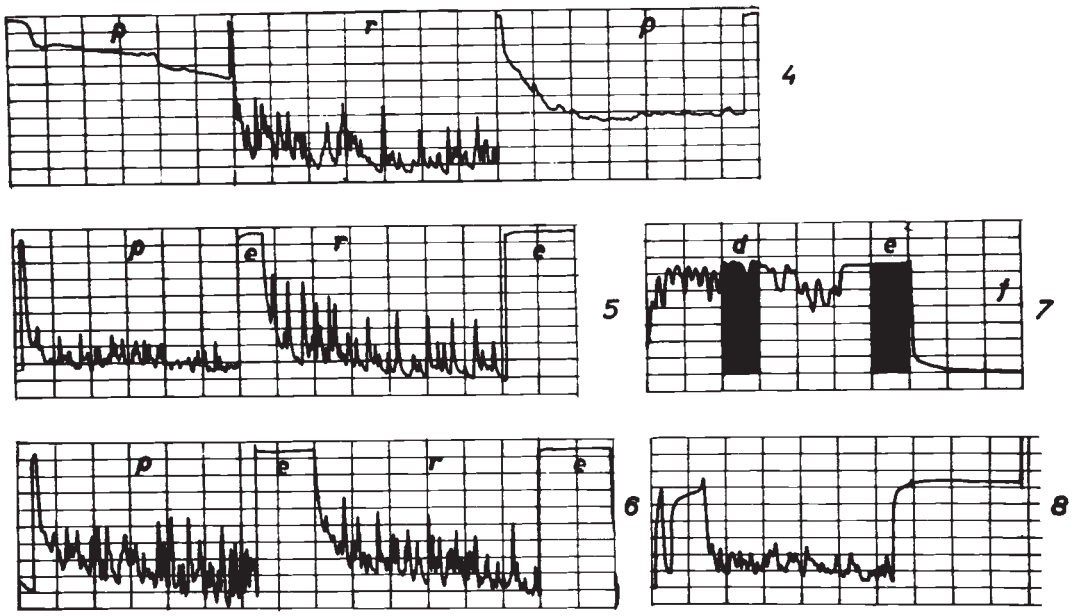
GRAPH 3. The prolonged duration of a sudomotoric response of an affected area (a) and of a control area in close vicinity to lichenification (b) (1 part=1 minute). The deviation between (a) and (b) is caused by manipulating with the sampling cell (S).

respond to a mild impulse. The response is still evident between the 10–11th minute in both locations. The unaffected area ceased to sweat in the 23rd minute of the continuous record whereas the output of the affected area is still evident in the 28–29th minute. A pilocarpine impulse on unaffected skin even in a lichenified area results in a continual sweat response (graph 4, p). The untreated portion of the location responds to an effort impulse with typical intermittent sweat output (r) which is almost inapparent in the pilocarpine treated part (p). The amplitude of the pilocarpine-treated area of skin is much lower (graph 5, p) than the control one (r) for as long as 4 hours later. There was an identical response in the pilocarpine-treated and in the control area after 12 hours (graph 6, p, r).

DISCUSSION

The above-described device is of help in confirming already established facts. Sweat output is of intermittent character cca 5–13 c/minute, the usual amplitude frequency being 7 (27, 28, 29, 30). This rhythmical character of sweat output is usually present both in so-called emotional sudomotoric locations (palms, soles) and also in those of eccrine thermoregulative sweating. An emotional sweat response may usually be evoked in a randomly selected skin location as long as the room temperature is high enough (above 26° C). A high room temperature, however, is inclined to have a depressing influence on the palm sweat-response to psychic impulses (31, 32, 33). Physical effort (squatting) is a reliable stimulant for eliciting cyclic sweat activity (one high amplitude following the other). If the influence of the thermoregulative centers is either too intense or too slight, sweating loses its intermittent character of high amplitudes, and its pattern becomes similar to the small waves of the basic rhythm. It is also possible to establish rhythms of a longer duration (one to several minutes) into which the basic wave-length is interpolated.

A pilocarpine iontophoresis (1% pilocarpine-



GRAPH 4. The response of the affected area (p) and the control area to pilocarpine and effort simulus in the form of continuous sweat secretion, the control area (r) showing typical intermittent sudomotoric activity.

GRAPH 5. 4 hours after the application of pilocarpine; the amplitude of the treated location is still lower than that of the control one. Moisture of room air records are again evident (e), among the measured ones.

GRAPH 6. It is not until 12 hours later that the treated and control area become equal

GRAPH 7. A sweat secretion record demonstrating the accurate calculation of the values: area of the recorded graph d = 280 mm², of recorded graph e = 290 mm², water contents in air 14.5 mg water (70% relative moisture, 23° C temperature). Flowing speed 5 liters per hour.

GRAPH 8. Analogous record at flowing speed of 20 l per hour

nitrate, 0.3 mA/1 cm², 5 min. 5.4 cm²) may be followed by characteristic sweat secretion (34) which is modulated by the frequently indistinct basic rhythm. Psychic impulses may sometimes be followed by a deviation, which is usually only slight. It is interesting to note that at the site of pilocarpine application the intermittent sweat response disappears; whereas it continues quite regularly when an effort impulse has been applied.

The observation that a more intense sweat output follows an effort, thermal and emotional stimulus in a lichenified area has been confirmed by our results (21). The fact that a threshold is involved is emphasized by the continuous character of the sweat output following a more intense impulse (like profuse sweating of healthy skin) and by the distinct reaction of affected skin to a stimulus which evokes practically no response in healthy skin areas. This seeming anomaly is not primarily restricted to certain localizations according to the pathogenetic significance of topographic differences in vegetative skin tonus (35, 36, 37). It is however related to the presence of chronic lichenification. An effort stimulus, or a psychic one, or the combination of both, applied to unilateral affected flexural areas is regularly followed by intense sweating, in contrast to the absence of reaction in the control flexors. Typical lichenified areas of atopic dermatitis respond to stimuli lower than threshold (for normal skin) with an intermittent cyclic secretion which may be graphically recorded according to the magnitude of stimulation as pointed or wave amplitudes. Furthermore, the duration of a sudomotoric response to stimuli which elicit responses even in control localizations is much longer in lichenified areas. As direct iontophoretic stimulation of muscarin receptor tends to depress the cyclic secretive activity of the eccrine sweat gland, it appears that the described phenomenon is not caused by direct stimulation of the neurosecretive junction by one of the mediators. It

seems likely that this is either the result of a lowering of the threshold for sudomotoric responses or the result of an increasing tonus of the axon of the sympathetic fibers (37, 38, 39, 40). A causative relationship may exist between this phenomenon and the well-known skin vasomotoric anomalies in atopics (delayed blanch phenomenon, white dermographism (41, 42, 43, 44)).

If the ramification of the sensory system may be considered to be a receptor of the sweat axon (37, 45), then it may also be suggested that vessel-active substances (such as bradykinin etc. 8, 46, 47, 48) excreted after stimulation of the eccrine sweat gland, not only stimulate sensitive receptors but also sweating.

SUMMARY

The differences in sweat secreting dynamics of typical lichenified areas in children with atopic dermatitis and in healthy skin areas have been studied. A resistance hygrometer with a small time constant ($\tau < 0.5$ sec.) based on a thin sensitive layer of NaCl and glycerine in Bentonite was used.

The sweat response to all kinds of different physiological stimuli is of a discontinuous intermittent character with an average number of 7 amplitudes per minute, both for the affected sites and for the healthy skin areas.

The most adequate stimulus for evoking a cyclic sweating response was physical effort. When the grade of stimulation is high, the sudomotoric record is rather of a continuous character with a more or less distinct basic amplitude.

A typical lichenified skin area of a child with atopic dermatitis, however, responds to such thermal, psychic and effort stimuli to which the adjacent skin does not. The sudomotoric activity is in the majority of these cases represented by salves of pointed amplitudes. Since a local stimulation (with pilocarpine) of the neurosecretive receptor results in a record of continuous character, it is suggested that the described phenomenon of increased sudomotoric activity in pathologic areas is caused by a decreased threshold of the sudomotoric nerves.

Shortly before the completion of this paper, we noted a similar method is described in the September issue of the Journal of Pediatrics 1963.

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